View metadata, citation and similar papers at core.ac.uk

brought to you by CORE

provided by Technical Disclosure Common

Technical Disclosure Commons

Defensive Publications Series

February 05, 2019

Thermal Downlink Throttle UE Specific Approach

Blake Kragten

Shivank Nayak

Siddharth Ray

Follow this and additional works at: https://www.tdcommons.org/dpubs_series

Recommended Citation

Kragten, Blake; Nayak, Shivank; and Ray, Siddharth, "Thermal Downlink Throttle UE Specific Approach", Technical Disclosure Commons, (February 05, 2019)
https://www.tdcommons.org/dpubs_series/1932

This work is licensed under a Creative Commons Attribution 4.0 License.
This Article is brought to you for free and open access by Technical Disclosure Commons. It has been accepted for inclusion in Defensive Publications Series by an authorized administrator of Technical Disclosure Commons.

Thermal Downlink Throttle UE Specific Approach

ABSTRACT

During operation, temperatures of a mobile communication device of an end user (user equipment or "UE") can increase to high levels. In particular, UE temperatures can rise when receiving large amounts of data during downlink communication with a network. Generally, there is no ability to limit the amount of downlink throughput when the UE device is in single carrier mode. However, downlink throughput throttling can be used to thermally mitigate increasing UE temperatures. As the temperature of the UE increases, the network can be notified to decrease the amount of downlink throughput, thus reducing the power levels and the temperature of the UE. Once the temperature of the UE starts to reduce, the network can then be notified to increase downlink throughput in a gradual manner.

DETAILED DESCRIPTION

The temperature of a UE can increase to high values during operation. For instance, temperature rise can occur when the UE makes high speed downloads, is placed in a hot environment (e.g., a car dashboard), or when the usage of the UE's graphical processing unit ("GPU") is high. Higher temperatures can cause the UE device to overheat, which can damage components of the UE and/or can cause the UE to shut down during operation.

Generally, a UE does not have the ability to limit amount of downlink data throughput provided by a network when in single carrier mode. As such, the UE may experience high power usage rates in order to continuously receive downlink data from the network or risk losing the information transmitted by the network. The high power usage rates for receiving downlink data can result in higher temperatures for the UE.

One method to control temperature rise involves using the Channel Quality Indicator ("CQI") to gradually control the downlink throughput from the network. The CQI indicates the quality of the communication channel between the UE and the network. Typically, the UE specifies the CQI value to the network. Depending on which CQI value the UE reports, the network will transmit data to the UE with different transport block sizes and throughput. For instance, if the network receives a high CQI value from the UE, the network can transmit the data with larger transport block size and therefore higher throughput.

Consequently, a UE can be configured to report CQI values in proportion to the internal UE temperature by using thermal throughput throttling. As temperatures of the UE rise, the UE can gradually decrease the CQI in order to notify the network to decrease downlink throughput, thus reducing the power usage required by the UE to receive the downlink data. With throttling, downlink throughput can be gradually decreased for a smooth transition in cooling the UE.

CQI Mitigation

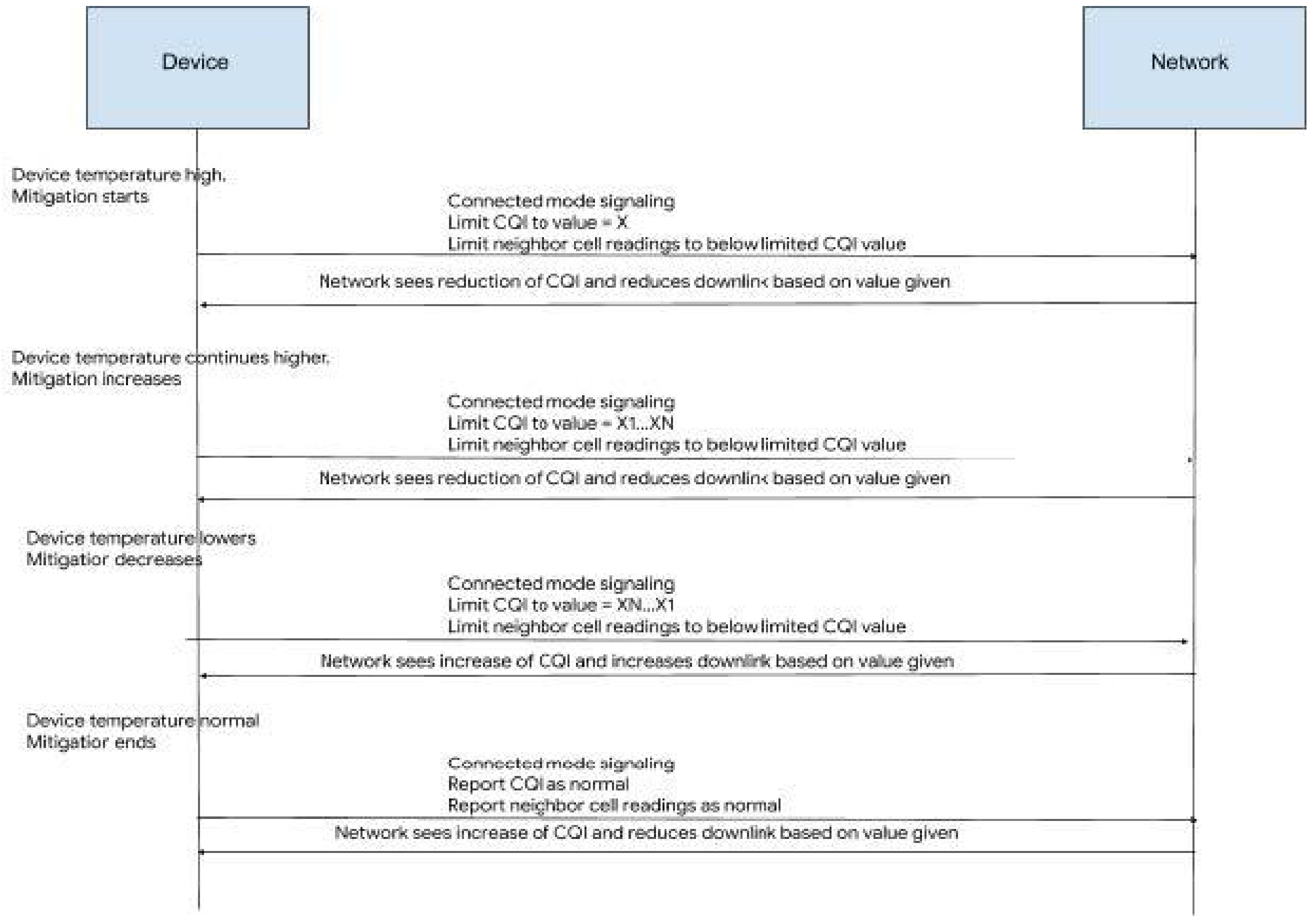

Figure 1 – Thermal Throughput Throttling between a UE and a Network

Figure 1 depicts functions involved in a thermal throughput throttling process between a UE and a network. The process of Figure 1 can begin when the UE determines that the device temperature is increasing past a predefined threshold temperature. Once past the threshold, the UE device begins thermal mitigation by reducing the CQI to a value X. The UE device then reports the reduced CQI value to the network and the network decreases the downlink throughput based on the reduced CQI value.

Furthermore, the UE can be in either idle or connected mode with respect to the network. While in connected mode, the UE may switch communication to a neighbor cell/neighbor base station due to degradation in the received signal from a current cell/current base station. For instance, the UE may switch to neighbor cell that reports higher CQI values then the current cell. To prevent the UE from flip-flopping between neighbor cells in search of a connection with a higher CQI, the UE can be configured to limit neighbor cell readings to below the reduced CQI value. Alternatively, neighbor cell searching can be disabled.

As the temperature of the UE increases, the process of Figure 1 continues with the UE gradually reducing the CQI to X_1, X_2, … X_N (where $X > X_1$, $X_1 > X_2$ and $X_2 > X_N$). Neighbor cell searching can be limited to the reduced CQI values and the network can further reduce the downlink throughput based on the reduced CQI values.

In time, the temperature of the UE may begin to cool down due to the reduced power required for the UE to receive the downlink data. As the temperature of the UE decreases, the UE can gradually increase the CQI value to X_N, X_2, … X_1. Limits on neighbor cell searching can be raised according to the increased CQI values and the network can gradually increase the downlink throughput to the UE based on the increased CQI values.

At some point the temperature of the UE may return back to a normal temperature level. For instance, the normal temperature level can be defined by the UE temperature falling below the predefined threshold temperature. Once this occurs, the UE can stop thermal mitigation and report the CQI as normal. Limits on neighbor cell searching can be removed and the network can revert back to normal operations with the downlink throughput to the UE based on the normal CQI values.

Reduction and Cooling Phases

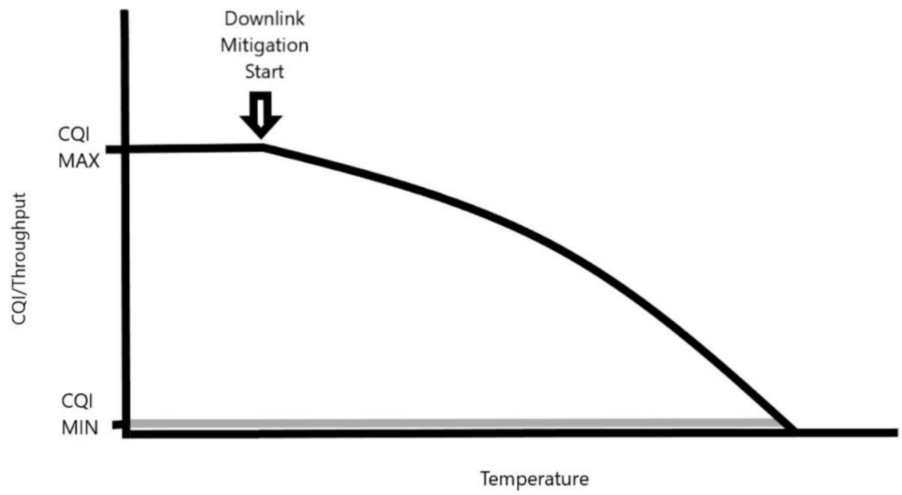

Figure 2 – CQI/Throughput vs. Temperature in CQI Thermal Mitigation

Figure 2 depicts the relationship between CQI and temperature that occurs during thermal mitigation. The horizontal axis depicts temperature values and the vertical axis depicts CQI values. As shown in Figure 2, thermal mitigation can be initiated when the temperature of the UE increases past a predefined threshold temperature. For instance, the predefined threshold can be based on the components of the UE device, the type of network, and/or other factors.

Thermal mitigation starts with a reduction phase. During reduction, CQI values will be gradually stepped down until a minimum CQI value is hit or when temperatures begin to cool down. Stepping down the CQI value occurs when specific temperature thresholds are hit. Each possible CQI value can have a temperature set point, to lower the CQI to that corresponding value, and a temperature clear point, to increase the CQI to the next higher value. For instance, CQI value 11 may have a temperature set point of 50°C and a temperature clear point of 47°C, while a CQI value 12 can have a temperature set point of 45°C and a temperature clear point of 43°C. As such, if the temperature of the device is 48°C, the UE may set the CQI value to 11.

Temperature set points and temperature clear points can be configurable and may be based on the components of the UE device, the type of network, and/or other factors. Moreover, temperature set points and temperature clear points can be stored on the UE for quick access and can correspond to the CQI values X, X_1, X_2, … X_N as discussed with respect to Figure 1.

Once the temperature of the UE begins to decrease, thermal mitigation enters a cooling phase. During the cooling phase, if the UE temperature decreases and hits the temperature clear point for the current CQI value, the CQI value will be increased to the next highest CQI value. For instance, if the current CQI value 11 has a temperature clear point of 47°C, a temperature decrease to 47°C will result in the CQI value increasing to 12.

The thermal mitigation cooling phase can end when the initial predefined threshold temperature is hit. If at any point the UE temperature begins to increase again and hits the initial predefined threshold temperature, the UE can reduce the CQI value to the first temperature set point and restart the thermal mitigation reduction phase.