**Question 2(b) - Enlist the benefits and drawbacks of the the proposed LoRaBLE protocol**

**Benefits of LoRaBLE protocol**

1. With LoRaBLE protocol, the benefits of both short and long range communication with bounded delays have been instituted utilising the BLE and LoRa protocols respectively, in order to meet time constraints of real- time industrial traffic flows.

2. The use of clusters to bind/ group neighbouring nodes which frequently communicates with each other has enabled communication without incurring network workload. This intra-cluster communication is also power saving as it is based on the BLE protocol. Further, Cellular network independency is the key benefit to reach distant far flung areas to monitor parameters from various IoT sensors.

3. It mentions about the time-constrained communications between a LoRa end node and another LoRa end node. Earlier approaches that have been proposed in the literature so far, mention are only able to provide bounded delays to time-constrained communications from a LoRa end node to the LoRa sink. Therefore, LoRaBLE fills a gap as far as real-time communications over LoRa networks are concerned.

4. **Backup connectivity**. If suppose due to some defect sensor is not able to send data or an area with low coverage from a low power wide area network (LPWAN), backup BLE connectivity can be used to access the accumulated data. This guaranteed backup access and control provides fail-safe connectivity and prevents loss of valuable information in IoT system.

5. **Asset Tracking Management**. For tracking valuable goods traveling on a container, LoRa is widely used to enable the tracking of moving assets with GNSS location scanning over a large geographic area. However, formulation of an infrastructure with BLE beaconing deployed can extend this asset tracking to indoor location coverage as well.

**Drawbacks of LoRaBLE Protocol**

1. Model is based on the assumption that each CB is located within the coverage range of all other CBs. It is known that the use of a high spreading factor value increases the Time of Arrival, and therefore exists a trade-off between bit rate and communication range. This will further limit the deployment of LoRaBLE protocol based IoT network to be applicable for soft real time applications, with cycle times in the order of tens of seconds.

2. It is also mentioned that the protocol is based on the based that nearby nodes are organized in one cluster. However, if the no of nodes exceeds the maximum permissible limit, it would cause network congestion. No discussion with regards to structure, protocol, topology to cater for multiple clusters is defined in the paper.

3. **Reliability**. Communication between cluster takes place over LoRa protocol via master of LoRaBLE cluster. In the event of failure of this master, there is no reliability for inter communication between clusters.

4. Also, on failure of Inter-cluster node, the scheduler non-availability will lead to crashing of whole system.

References:

1. https://blog.semtech.com/lora-combined-with-ble-creates-complementary-hybrid-iot-connectivity

**Question 2(c) - Explain the LoRaBLE protocol topology in your words. Come up with an alternate protocol design to avoid drawbacks of the the proposed protocol. (Hint: use of different communication protocols, change in topology, modify the Inter-cluster scheduling algorithm, modify the superframe architecture etc.)**

**LoRaBLE protocol topology** : As we have studied, that the two protocols viz. LoRa and BLE both have their pros and cons. However, this protocol is designed to derive the best of features of both BLE and LoRa protocol in order to realise a network efficient, wide scale network with bounded time delay for soft real time network.

The topology is based on a hybrid model which includes clusters of BLE nodes and a LoRa inter-cluster scheduler. The BLE-LoRa bridges called as Cluster Bridges(CBs) messages between clusters. A BLE node exchanges messages with its Cluster Bridges where the similar function nodes assigned in nearby locations forms a cluster and are linked with LoRa device which is Master for that particular cluster. These multiple clusters performs inter-cluster communication unidirectionally or bidirectionally using Time-Division Multiple Access (TDMA) approach. This inter-cluster communication is governed by a Inter-cluster scheduler which periodically sends a beacon that synchronizes all the CBs and indicates the start of the superframe.

Methods to improve existing Protocol:

1. By putting two LoRa nodes in a cluster as primary and secondary master node to add reliability factor. In this case, the data from BLE nodes will be replicated between both the LoRa nodes. In case of failure of primary, which can be detected by absence of beacon signal from it, secondary LoRa node will take over duties of master of cluster.
2. Similarly, putting a secondary Inter-cluster node to perform task of scheduler is essential to backup the system incase of failure of primary inter-cluster node. This will enhance the reliability in the network and thus enable seamless network flow.