Impact of Compression and Aggregation in Wireless Networks on Smart Meter Data

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Background

In addition to the power system the Smart Grid relies on Information and Communication Technology (ICT) to manage data on the grid status. As the smart grid is deployed, the data volume will increase dramatically. Due to the very large data volume, **data compression** is a necessary technique. The most important reasons for compression are :

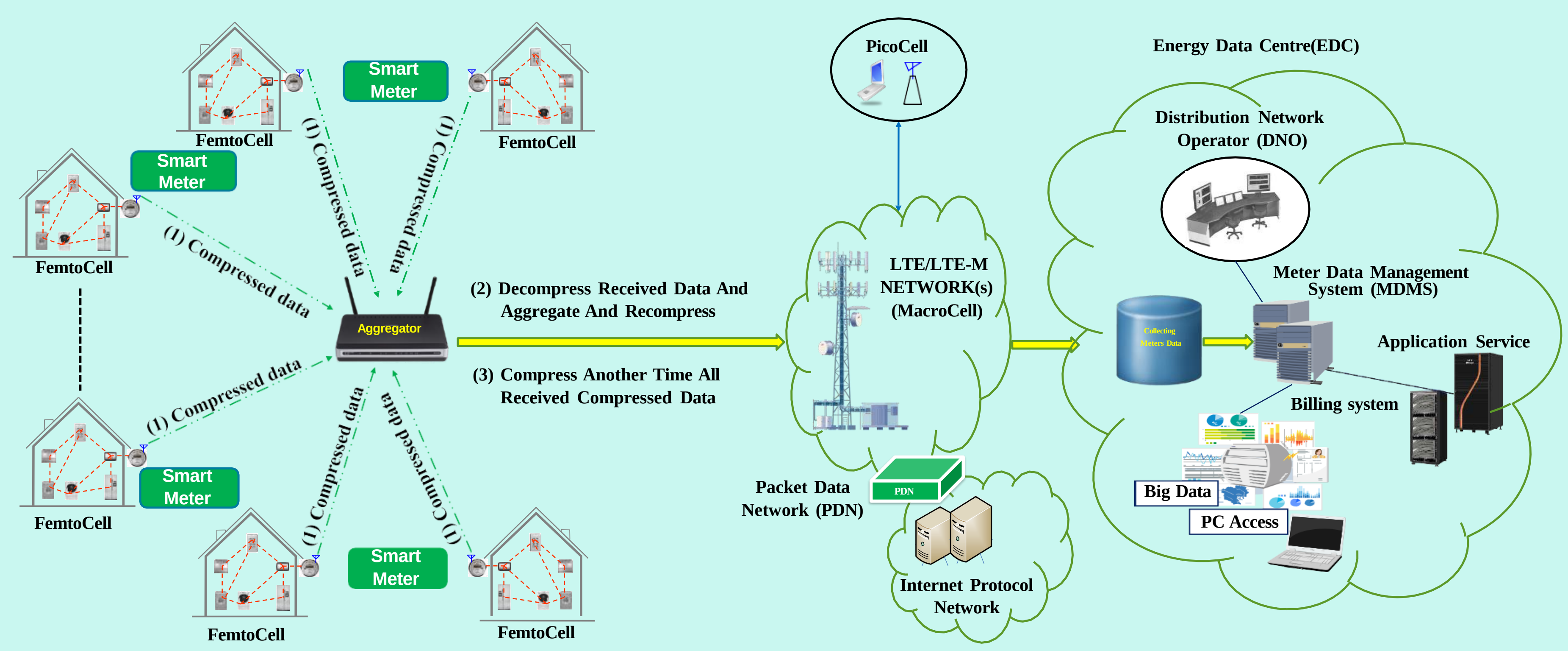
- ❑ Reducing Data volume
- ❑ Communication bandwidth Efficiency
- ❑ Energy efficiency

In this work, we present lossless compression algorithms that are suitable to be implemented in smart meter hardware without considering the features of the collected data. Because of that they are compatible with a wide range of smart meter data formats. We assess these algorithms using two different sets of real smart meter data and compare the compression results.

Compression Methods

As mentioned before two compression methods are considered in this work.

- ❑ **Lempel-Ziv-Welch (LZW)** is dictionary base compression algorithm and the idea is to (1) start with an initial model, (2) read data piece by piece, (3) update the model and encode the data on the fly.
- ❑ **Adaptive Huffman (AH)** is a simple algorithm: (1) Start with a maximally "flat" code tree. (2) Code *N* symbols from the source and at the same time gather statistics, ie count how many times each symbol appears. (3) Build a new Huffman tree with the new estimated probabilities. (4) Repeat from step 2 until data encoded.

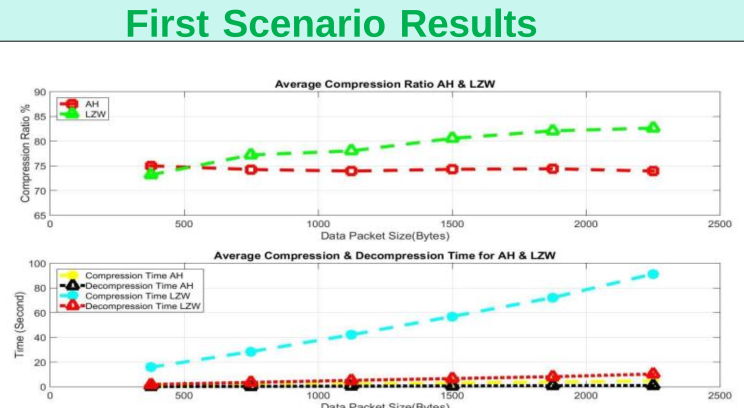


Aggregation Methods Description

- ➢ **First scenario:** In this communication scenario, compressed smart meter data from the meters are sent to the aggregator, which are simply forwarded directly to the EDC through the internet without further processing.
- ➢ **Second Scenario:** in this set-up we perform processing in the aggregator in contrast to the first scenario. The aggregator received the compressed data from each smart meter and decompresses it and aggregates a group of packets together into one larger data packet. This data is then compressed again to reduce the size of transmitted data through cellular network backhaul connection to the EDC.
- ➢ **Third Scenario:** in the last scenario we aggregate the received compressed smart meter data, but this time we compress again all of the received data packets in the aggregator without uncompressing it first. This approach could be called double compression to reduce complexity while still increasing the total compression ratio.

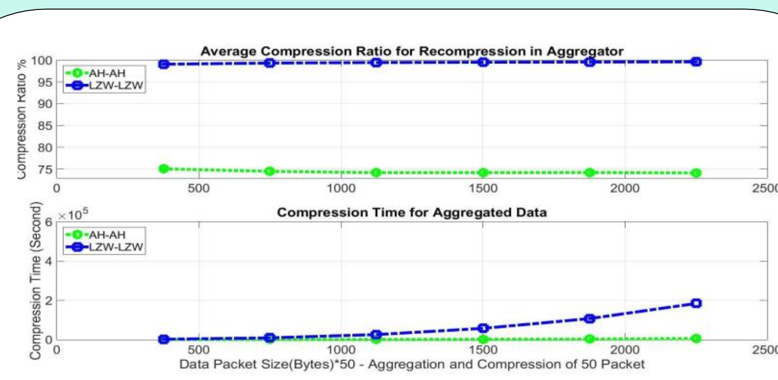
Results

First Scenario Results



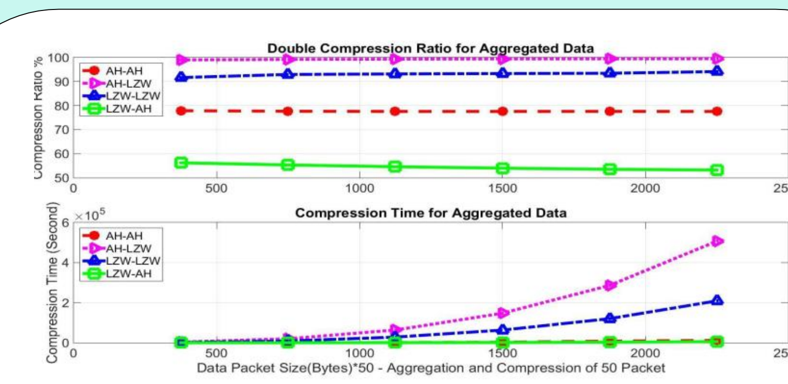
The applied techniques achieve average compression rates of 74-88% for the LZW method. If low execution times are mandatory, the AH algorithm is the best choice, achieving approximately 74% compression rate for all packet sizes.

Second Scenario Results



both meters and aggregator using AH (AH-AH) or LZW (LZW-LZW) It easily can be seen that the LZW approach shows a higher compression rate which is expected from Fig. 2 due to the larger data packet size after aggregation.

Third Scenario Results



We applied the compression algorithm inside the aggregator on compressed packets received from 50 smart meters. The results shows that the best compression ratios are obtained when LZW techniques are applied in the aggregator after AH compression on smart meter.

Conclusion

This paper has investigated the performance of compression and aggregation techniques for smart meter data. For large dataset sizes, the LZW algorithm achieved higher compression rates and consequently saves bandwidth for communication, at the cost of higher complexity. The AH algorithm with lower processing times could save more energy, time and Hardware requirements when implemented in smart meters. The trade-off between compression rate, processing time and hardware requirement can lead us to the best selection of compression algorithm for each part of our communication scenario. The double compression approach (scenario three) which uses the
AH approach in the smart meter followed by the LZW method in the aggregator is the best choice (with 98-99% compression ratio) as the size of the aggregated data will increases significantly and we expect that the aggregator will have more processing power to implement the more complex LZW algorithm. In future work, alternative compression algorithms to the LZW and AH methods should be investigated while the effect of errors and packet losses on the communication channels should also be considered.

References

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