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# Total Order Reliable Convergecast in WBAN

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## ABSTRACT

This paper is the first extensive work on total order reliable convergecast in multi-hop Wireless Body Area Networks (WBAN). Convergecast is a many-to-one cooperative scheme where each node of the network transmits data towards the same sink. Our contribution is threefold. First, we stress existing WBAN convergecast strategies with respect to their capacity to be *reliable* and to ensure the *total order* delivery at sink. That is, packets sent in a specific order should be received in the same order by the sink. When stressed with transmission rates up to 500 packets per second the performances of these strategies decrease dramatically (more than 90% of packets lost). Secondly, we propose a new posture-centric model for WBAN. This model offers a good characterization of the path availability which is further used to fine tune the retransmission rate thresholds. Third, based on our model we propose a *new mechanism for reliability* and a *new converge-cast strategy* that outperforms WBAN dedicated strategies but also strategies adapted from DTN and WSN areas. Our extensive performance evaluations use essential parameters for WBAN: packet lost, total order reliability (messages sent in a specific order should be delivered in that specific order) and various human body postures. In particular, our strategy ensures zero packet order inversions for various transmission rates and mobility postures. Interestingly, our strategy respects this property without the need of additional energy-guzzler mechanisms.

## Keywords

Wireless Body Area Networks, Total Order Reliable Convergecast, Networks Modelization

## 1. INTRODUCTION

Wireless Body Area Networks (WBAN) is a cross-area between Wireless Sensor Networks (WSN) and Delay Tolerant

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Networks (DTN) with as main objective the collection of physiological parameters from sensors deployed on a human body that undergo the human mobility. Designing efficient protocols for this area is a challenging task. One of the particularities of the WBAN area are the specific rates of the physiological parameters monitoring. In [1] the authors advocate that in the current applications of WBAN, the transmission rate is less than 10 packets per second. However, these rates may drastically increase in the future. Therefore, in order to meet the requirements of medical monitoring, WBAN is needed to withstand a continuous packets flows. In some critical applications such as monitoring patients during a surgery or post-surgery the flows carry vital alerts. Missing some of them or wrongly interpret the flow of data due to packets inversions may have a tremendous impact. In this context designing efficient total order reliable protocols is crucial for saving human lives.

In this paper we focus the *convergecast* communication primitive since this is one of the main building block in WBAN. Convergecast allows nodes to transmit data towards a sink. Convergecast has the total order property if packets are delivered at the sink in the same order as they have been transmitted.

Recently, [2] surveys the existing work on convergecast on various areas including Delay Tolerant Networks, DTN and Wireless Sensor Networks, WSN. They argue that most of the existing strategies are not directly implementable in WBANs due to their needs in computing capacities, memory or their energy consumption. Finally, building on top of [3, 4, 5, 6, 7], they propose and evaluate three classes of convergecast strategies tailored for WBAN: 1) Multi-Paths based strategies, 2) Attenuation-based strategies and 3) Gossip-based strategies. Their evaluation does not target the total order delivery property of these strategies neither their resistance to increasing flows of messages. It merely focus on the resilience to the human body mobility and energy consumption. They measure the following parameters: percentage of received messages (under the hypothesis that each node sends a single message in each run), end-to-end delay and the number of transmission/receptions since this is a good indicator of the energy consumption.

In terms of *reliability*, to the best of our knowledge there are three main reliability mechanisms used in WBAN. The first mechanism computes and presets a static or dynamic overlay path for collecting data. Strategies proposed in [8, 9] and attenuation-based strategies in [2] choose a reliable leader or a set of relay nodes as the next hop(s) to help in forwarding the packets. Strategies proposed in [10, 11,