Experimental Evaluation of Bluetooth Real Time Capabilities in Communication Intensive Applications

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***Abstract*- During the last years Bluetooth (BT) standard has received increasing acceptance as a prominent communication technology concerning a wide variety of critical applications, posing demanding communication and strict real time constrains. In that respect the main objective of this paper is to offer comprehensive experimental evaluation analyzing BT time constrained performance and critical network parameters. Performance evaluation presented focus on specialized real-time metrics, such as, standard delay deviation, and delay distribution measurements. The study presented, through qualitative and quantitative analysis, reveals significant observations and conclusions. Furthermore, critical trade-offs are presented as far as network conditions are concerned, facilitating optimal network configuration with respect to realistic requirements and parameters posed by critical applications such as medical ones.**

Keyword: Short Range wireless networks, Experimental Study, Critical Applications, Medical Measurements' Requirements, Bluetooth Technology, Real-Time Constrained Performance, Delay Deviation, Delay distribution, Bluetooth Development platform.

I. INTRODUCTION

Short-range wireless communication paradigm offers significant advantages leading to active interest both by academia and industry [1,2,3]. One of the most well-known and widely used technologies of respective communication area is the Bluetooth standard (BT) [7]. This is due to its main advantages over counterpart technologies, which propelled the degree of acceptance and its widespread use in actual commercial implementations, addressing a wide range of application scenarios [4,5,6]. Bluetooth technology encompasses all the advantages of short range wireless communication, while mitigating respective shortcomings often encountered in Personal Area Networks (PAN) networks (e.g. IEEE 802.15.4) mainly related to limited performance capabilities [8].

Over the last years, BT devices have been utilized in a substantial variety of demanding applications, such as high quality video and audio transfer, as well as, for critical applications such medical data acquisition and wireless transferring [9, 10]. Even more Bluetooth protocol poses as a prominent relative radio technology adopted as the main communication infrastructure of many medical commercial products [11,12,13].

Critical applications are characterized by strict time constrained communication requirements. For example, when video transmission is considered metrics such as packet delay deviation and packet delay distribution, comprise the most important performance metrics. However, since BT technology is not typically considered as a real-time capable solution, relative performance evaluations rely on less detailed and network wide performance metrics (i.e. mean packet delay, mean throughput etc) thus omitting specialized performance parameters of paramount importance pertaining to the time constraint communication capabilities [16, 17]. Furthermore, most relative efforts rely on simulation based evaluations of questionable accuracy and validity.

Aiming to enhance in-depth knowledge in this area, in this paper an experimental evaluation study is presented focusing specifically on real-time performance relying both on qualitative and quantitative analysis. Focusing on the respective metrics, while using a highly flexible and configurable BT based development platform [14] and varying critical network parameters, the paper draws valuable conclusions concerning BT capabilities and trade-offs.

The rest of this paper is structured as follows. Section II presents a detailed configuration analysis of the undertaken effort, while Section III analyses the main results of the experimental evaluation. Finally Section IV discusses the main conclusions and presents the future directions of this effort.

II. CONFIGURATION OF EXPERIMENTS

Aiming to offer useful, objective and comprehensive evaluation the following network parameters are taken into consideration:

- Traffic workload imposed by respective data flows. Low traffic rate corresponds to 10 packets transmitted per second or to a 10 Hz packet creation frequency adequate for accelerometer or ambient measurements. High traffic rate corresponds to 1000 packets transmitted per second i.e. 1 kHz adequate for EEG data acquisition.
- Concurrent transmitting nodes lead to competition and need for channel arbitration and scheduling. In that respect, 1 aggregation node and data creating nodes varying from 1 up to 6 concurrently transmitting BT nodes are considered.
- Data packet size assumed values equal to 9, 15 and 20bytes.