Cognitive Aeronautical Communication System

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ABSTRACT

The paper explores the system and architecture requirements for cognitive driven reconfigurable hardware for an aeronautical platform, such as commercial aircraft or high altitude platforms. With advances in components and processing hardware, mobile platforms are ideal candidates to have configurable hardware that can morph itself, given the location and available wireless service. This paper proposes a system for an intelligent self-configurable software and hardware solution for an aeronautical system.

Keywords: Aeronautical Data Networks, Aeronautical Systems, Cognitive Data Networks, OFDM, Software Defined Radio

INTRODUCTION AND OVERVIEW

Wireless connectivity has come a long ways in providing reliable and bandwidth efficient data connectivity. Given the limited resource in multi-dimensional electro-space, i.e. time, frequency, space, polarization, modulation/orthogonal signalization; an increase in data rate can be achieved through multi-dimensional resource efficiency. To achieve higher spectral density (Wertz & Larson, 1999), higher signal energy over noise ($E_b/N_o$) is required (Signal Processing Design Line, n.d.) to support the different links.

In the past few decades, the increased time spent in the air by higher numbers of users (Bureau of Transportation Statistics, n.d.) is creating a demand for data in in-flight services (Lai, 1998). In addition, the aircraft can be used as a relay. Therefore, aircraft based Aeronautical Data Networks (ADN) for future wireless communication structure is increasingly being discussed. All programs lead by National Aeronautics and Space Administration (NASA), Federal Aviation Administration (FAA), European Union (EU) and EUROCONTROL are including the aeronautical platform as part of the network (NASA, 2009; Gilbert, Jin, Berger, & Henriksen, 2008; Newsky, n.d.). A key enabler would be a robust physical layer. From the networking point of view, there are a couple

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of studies, where in-flight internet with both aeronautical ad-hoc networking and centralized manner strategies are discussed (Sakhaee & Jamalipour, 2006; Medina, Hoffman, Ayaz, & Rokitansky, 2009). The global movement of the aeronautical system can take advantage of emerging wireless services and standards. This paper explores the concept for a Cognitive Aeronautical Software Defined Radio (CASDR). The organization of this paper is as follows: the following section discusses the driving motivation for CASDR. The CASDR system requirements are then established. In addition, the problem statement for Doppler and its effects to the physical layer in aeronautical scenario are investigated. The proposed hardware system definition for aeronautical software defined radio is given. In the last section, conclusions and a roadmap for future studies are provided.

**MOTIVATION AND CHALLENGES**

The ever-changing geographical environment of an aircraft and an increasing availability of different wireless services makes one wonder, what if such services can be accessed in real time?

This provided the motivation to develop a concept system and its hardware that would accommodate to the rapid changes, not just due to the aircraft location, but also to support the growth of services and industry evolution.

Figure 1 depicts the notional framework of opportunistic wireless data service that may be available for an aircraft in flight. At higher altitude the services may be more traditional and fixed, however on ground, the growing WiMAX and local area network services may be available to be accessed from the aircraft. The high-speed mobility of an aircraft adds additional challenges to the design of system physical layer, such as path loss and multi-Doppler spread (Medina et al., 2008; Erturk, Haque, & Arslan, 2010).

**REVIEW OF LITERATURE**

The desire for a universal and a reconfigurable terminal first appeared in the military area. The need for mobility and accessibility was the driving requirement. One of the early concept was a reconfigurable system appeared as an equipment called “SPEAKeasy” (Lackey & Upmal, 1995). The Software Communications Architecture (SCA) developed by the Joint Tactical Radio System (JTRS) program of the U.S. Department of Defense (DoD) further fueled the growth of SDR (JTRS Enterprise, n.d.). JTRS aims to provide a family of digital, configurable, multiband, multimode, modular radios to alleviate communications interoperability problems. Finally the work of Mitola (1995), there is now a growing interest in reconfigurable terminals.

The increase in air traffic is resulting in the surge of commercial airborne communication system (European Organization for the Safety of Air Navigation, 2008). Aircell and AeroSat have developed the ground based hardware and now offer in flight Internet service. Aircell uses a concept of air-to-ground link (Blumenstein, 2007) and provides the in-flight Internet service called ‘gogo’ on aircrafts. GOGO service works of cellular phone base stations in the continental US, which act as access points for an en route flight. A recent flight from Tampa, Florida to Detroit, Ohio USA, a user using GOGO service experienced an average upload speed of 0.27 Mbits/s and an average download speed of 0.33 Mbits/s with latency of 233ms. However, the ground based service is limited to flight coverage over land only. For the oceanic flight satellite based connectivity is required. AeroSat developed satellite communication (SATCOM) Ku band for commercial airliners (AeroSat Corporation, 2008). This offers broad connectivity, however the cost and data throughput of satellite based service is not conducive to user demand.

The growth in SDR has been enabled by advances in semiconductor, which has led to
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