

# PROSES – Network Communications for the Future European ATM system

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## ABSTRACT

This paper introduces the PROSES (network PROtocol for the Single European Sky) project, which is aimed at defining and developing a communication protocol integrated in the future air connectivity scenarios providing high performance in environments where connectivity is degraded or intermittent, for its integration in the SESAR (SES ATM Research) program of the European Commission. The protocol is based on the use of mobile agents along with Delay Tolerant Networking (DTN) principles, in order to allow greater automation for network nodes, which in this case will be the aircraft and ground control centers. The developed protocol will be tested and validated using network emulation tools and flight tests using unmanned aircraft.

## Keywords

SES, ATM, SESAR, DTN, routing, air traffic management, mobile agent.

## INTRODUCTION

The year 2020 will mark a turning point in the field of European air traffic management (ATM) and control, as the next evolution in ATM is expected to become fully operational and deployed. The Single European Sky (SES) initiative will unify the heterogeneous air traffic control models used by each country, transforming the European airspace into a single integrated air management scenario.

In order to achieve this, the system will require an unprecedented level of connectivity between all the participants to support the massive increase in data exchanges taking place between the terrestrial, aerial and

satellite platforms. This paradigm shift implies an evolution from the traditional voice-based communication scenario to include massive man-to-machine and machine-to-machine data communication scenarios. In conclusion, a sort of “aerial ATM Internet” is being created, composed of mobile and collaborative nodes.

The correct deployment of the SES initiative will depend on network connectivity able to support multiple applications at the same time. However, the mobility of the network elements derives in a dynamic topology where communication links cannot be always maintained. This lack of stable connection is unacceptable from an integrity and security point of view. Besides, the degree of interoperability required by the multiple different participants implies the use of a common set of communication protocols. The most common one, TCP/IP, breaks down when confronted with intermittent links, delays and different data rates; all possible characteristics of a future SES scenario.

Hence, PROSES was conceived to tackle these issues and offer a stable and reliable communication solution for the future Air Traffic Management framework in Europe. The starting point of our research has been Delay Tolerant Networks, a scheme originally created [1], [2] to answer the difficulties of deep space communications, and currently being applied in other scenarios thanks to its possibilities. Our objective is to transfer this concept to ATM to design a protocol oriented to every possible participant operating in SES: manned and unmanned flights, ground ATM systems and telecommunication satellites.

## TECHNICAL DESCRIPTION

Traditionally, computer networks have been designed using protocol stacks schemes organised in several layers, with the theoretical OSI model from ISO being the more representative standard. The first ideas on DTN still use this scheme, posing it as an additional “overlay” layer providing the application layer with the support needed to

withstand the problems derived from disrupted connectivity and delays in data exchange. However, the current proposals of DTN models do not effectively answer a number of issues, mainly regarding the routing problem and its underlying processes.

Unlike the Internet, where the routing protocols are well defined (i.e. BGP, RIP, OSPF, etc...), the DTN networks do not seem to have a wide accepted set of standard routing protocols. In spite of the efforts made by the DTNRC, who have drawn up two different drafts of routing protocols [3], [4] the research community continues providing new many different approaches. A consensus of a generic routing strategy valid for every scenario does not seem to exist. From the point of view of the authors, the reason of this disgregation of protocols is prompted by the intrinsic characteristics of the DTN networks and its applications. That is, there is a strong dependency between the routing protocols and the applications. The obvious solution is to allow the information to decide for itself, since it knows which the best next hop is in a routing path for a certain time instant and context. Thus, the routing will depend on the application, rather the characteristics of the underlying network such as node movements, node availability, etc.

PROSES introduces a layer-less DTN conception, doing away with the hierarchical model of tiers and instead proposing a model based on several modules interacting without rigid interactions. This novel communication model for DTN networks requires a basic communication service beneath, the so called Network Abstraction. This abstraction defines a set of minimum specifications in order to maintain an effective connection between the nodes.

Taking into account our previous assertion, the mobile code – and the mobile agents in particular – is a clear way to provide a solution of a multi-routing protocol scenario like in the DTN networks. PROSES is sustained through the use of mobile agents, software entities moving from host to host in a network, and able to support several routing schemes simultaneously. In this sense, our proposal for the PROSES environment is to use the JADE framework as the basis of our infrastructure. JADE (Java Agent DEvelopment Framework) is a software framework written in Java for FIPA-compliant [5] multi-agent which supports mobility. In fact, a modified implementation of the Inter-Platform Mobility Service (IPMS) module [6] of the JADE framework has been made in order to overcome the main problems of the DTN routing. This gives us the opportunity of introduce as many routing protocols as applications we want to deploy, just only by imposing the restriction that every node must include a JADE platform.

## PRACTICAL EVALUATION OF METHODS, TECHNIQUES AND TOOLS

One of the main features that characterize SESAR is a massive increase in data communications between the participants in European ATM. The system that will provide the new networking functionalities is called SWIM (System Wide Information Management [7]). This infrastructure will integrate distributed and/or geographically sparse services, like external third party services (e.g. weather information services), monitoring systems, by means of the different communication links (air-ground datalinks, satellite, grounded networks...). SWIM is still in development and its implementation is far from being a reality in the short term. Therefore, PROSES identifies a number of scenarios where it is possible to improve the connectivity and interoperability of SWIM using the DTN approach, as an intermediate step towards its full deployment or as a complementary system to augment its planned capabilities.

In order to select the PROSES scenarios, the project team has focused on the situations where connectivity is not fully assured and the introduction of a new system able to withstand interruptions would be useful. Another research line is to act as a secondary system in a SWIM environment, offering certain low-cost services with non-critical requirements to ATM activities. This study has resulted in the selection of two main scenarios:

- Total connectivity. Nowadays, there are certain airspace sectors, mainly during transatlantic flights, where the surveillance radar systems provide no coverage and the pilot must periodically contact the ground ATC facilities by voice communication to update the aircraft position. However, the update rate is quite low and only very basic information can be exchanged this way. PROSES will provide mechanisms to automatically update the aircraft position in this scenario increasing the update rate using other airplanes as relays to send the information to the ground ATC facilities.
- Non-critical data exchange. PROSES is aimed to support the interconnected scenario provided in SESAR by offering users a set of basic data communication services (e.g. e-mail, SMS) using air-ground communication capabilities without the need of costly, additional equipment onboard.

PROSES will also support the inclusion of general aviation users in the Single European Sky. The implementation of the SESAR technology brings a radical change to ATM users like the general aviation sector, mainly in terms of new equipment and certifications needed to operate in the new ATM framework, with the corresponding consequence in cost. PROSES can bridge the gap between them and SESAR as a complementary connection method and

transmit their flight information without the need of a satellite link. At the same time, this argument is transferable to another group of participants which will undoubtedly be a factor to take into account in the long term: unmanned airplanes.

These scenarios will be tested two-fold. First, a number of software simulations will be developed to test the suitability of using mobile agents to exchange information between virtual nodes in our framework.

Second, the PROSES consortium has a number of fixed-wing UAVs at its disposal with payload capacity ranging from 2 to 7 Kg (Figure 2), to perform real flight tests to assess the performance of the developed protocols in emulated air traffic scenarios.

The project is currently finishing the conceptual phase and it is about to begin the integration of the developed protocols in the emulation tools as well as designing the simulation environments and final flight tests. The project team expects to obtain the final experimental results by the end of the year.

## CONCLUSIONS AND RECOMMENDATIONS

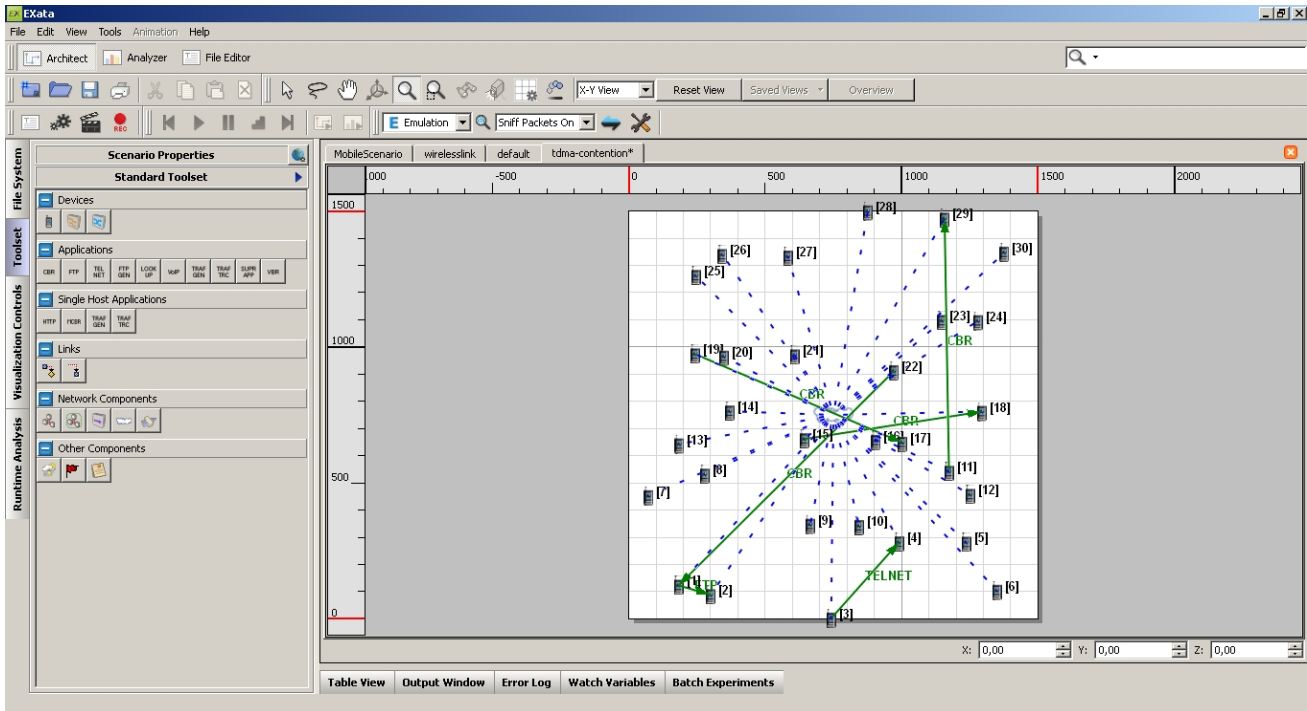
The transformation of the European Air Management System brings a set of challenges to the table which have not yet been fully answered. PROSES seeks to take advantage of the new communication landscape by proposing a novel architecture based on Delay Tolerant Networking and mobile agents. Simulations are about to get underway, with the next step being uploading the protocol aboard out unmanned drones to perform test flights in the south of Spain.

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**Figure 1 - Screenshot of the EXata network emulation and simulation software to be used in PROSES**



**Figure 2 - CATEC's UAVs that will be used for PROSES field experiments**